ARMORED MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

Report On

PROJECT NO. T-8 - Test of Harness, Man, M-1944, Type 1, OQMG Project No. 257-43

Project No. T-8

6 March 1945

Serial

U.S. Armored medical research laboratory,
Fort Knox, Ky.
Project no. T-8

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SPMEA 727 6 March 1945

1. PROJECT: No. T-8, Test of Harness, Man, M-1944, Type 1, OQMG Project No. 257-43.

a. Authority: Third Ind. Headquarters, ASF, to letter OQMG, dated 7 December 1944, File SPROG (23 October 1944).

b. Purpose: (1) To determine whether Harness, Apron Type, Double Trace, Type 1, is a substitute for Harness, Man, M-1944, Type 1; and (2) to ascertain whether harnesses having straps which cross the chest, interfere with respiration.

2. DISCUSSION:

a. Harness, Man, M-1944, Type 1 (Photo 1) and Harness Apron Type, Double Trace, Type 1 (Photo 2) differ primarily in that the former has an abdominal band, and the latter, a chest apron against which the propelling force is applied. This evaluation of their physiologic characteristics deals principally with the question whether one type produces more interference with respiration than the other. In addition certain other pertinent considerations are commented upon. For purposes of comparison towing trials were also carried out with an improvised Tump Line (Photo 3), since this type of harness is not in contact with the torso at any point and is a well established method of towing.

b. Details of procedure and results are given in the appendices.

3. CONCLUSIONS:

a. The Harness, Apron Type, Double Trace, Type 1 does not interfere significantly with breathing, whereas Harness, Man, M-1944, Type 1 may do so.

b. The Tump Line Harness is unsatisfactory for men untrained in its use.

c. Harness traces should be more than 5 feet in length.

d. Pain is produced by harness shoulder straps.

4. RECOMMENDATIONS:

a. That Harness, Apron Type, Double Trace, Type 1, be regarded not only as an adequate substitute for, but as physiologically preferable to, Harness, Man, M-1944, Type 1.

b. That consideration be given to measures for reducing pressure on the shoulder.

c. That the traces be a minimum of 7 feet long if they are to be provided as an integral part of the harness.

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4 Incls.
#1 - Appendix A
#2 - Appendix B
#3 - Figs 1, 2
#4 - Photos 1, 2, 3

APPENDIX A

PROCEDURE AND RESULTS

1. Test Courses

a. Two field tests were conducted to determine the functional utility of the Harness, Apron Type, Double Trace, Type 1, the Harness, Man, M-1944, Type 1, and an improvised Tump Line. For the first test, a hard surface tar and gravel road with a 6% grade was selected. At the start of the test in the morning, there was a thin film of ice on the road, which subsequently thawed, and later became partially covered with mud and slush following a light rain. Consequently, the ground friction of the weighted 24" x 30" sled with 2" x 4" wooden runners increased as the day progressed. At the same time the traction under foot was slightly improved.

b. The second test was over a cross country course of more than a half mile length. As indicated in the profile drawing in Fig 1, it provided several slopes of varying steepness. On this day, the muddy ground, irregular from previous tank travel, was frozen hard when the test began, but thawed progressively to greater depth as the day became warmer. Thus the effective load was increased by mud clinging to the sled runners, while foot traction was diminished by the increasing softness of the ground. In the course of this test, partial compensation for the changing ground conditions was afforded by lightening the load on the sled as much as 40%; but it is not certain that this was sufficient. It is apparent that complete control of the experimental conditions was not at all possible. For this trial the subjects wore Combat Uniform C, Pack, Field, and Belt, Pistol with canteen. They discarded their overshoes upon discovering that the footing was better without them. Each man was required to pull the weighted sled over an 800 yard course with each of the different harnesses.

2. Subjective Responses

There was no question about the preference for the Harness, Apron Type, Double Trace, Type 1, since the broad apron more effectively distributed the pressure over the body surface. The Tump Line was the poorest because of the unaccustomed tension imposed on the neck muscles, resulting not only from the pulling effort, but also from the necessity to counterbalance the eccentric drag of the strap over the head.

The obstruction to breathing produced by Harness, Man, M-1944, Type 1, was readily apparent from the subjective experiences of the subjects. They invariably reported that when the load being towed was jolted by an obstacle, the abdominal strap struck the abdomen sharply and interfered with breathing. Since

it is stated that in deep breathing, excursion of the diaphragm is responsible for approximately 60% of lung expansion* it is probable that a sudden increase of intra-abdominal pressure was responsible for the effects noted. Using the Tump Line, the men reported that there was constant severe tension on the neck even with relatively light loads, and that when obstacles were struck by the sled, the neck was invariably twisted and the neck muscles were reflexly tensed.

In summary, the subjective evidence clearly defines the following order of acceptability of the three towing harnesses:

a. Harness, Apron Type, Double Trace, Type 1.

b. Harness, Man, M-1944, Type 1.

c. Tump Line.

3. Physiological Observations

For the measurement of the physiologic effects of the harnesses to have yielded precise information, it would have been necessary to have used a large number of subjects over a period of many days, working on terrain whose character was unchanging. But as previously mentioned, the terrain and environmental conditions were highly variable, and accordingly, the data collected are not altogether comparable. In general, however, the following inferences may be drawn from them:

a. That the Harness, Apron Type, Double Trace, Type 1, whose apron covers the entire chest, imposes no more, and possibly less interference with respiration than the Harness, Man, M-1944, Type 1, in which the pressure bearing strap is applied against the abdomen.

b. That the Tump Line as used by untrained men is inferior to either of the body harnesses.

In the first test (Table 1) the weighted sled (total 230 lbs) was pulled over a measured uphill course 150 yards long. Although there were several subjects, only two (2) of these completed the test sufficiently well to provide comparative respiratory data for the three types of harnesses. The respiratory measurements were made by fitting a nose clamp and mouthpiece to each subject and leading the expired air into a gas flow meter through a valve assembly and rubber hose.

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* Best and Taylor, The Physiologic Basis of Medical Practice, Baltimore, Md., 2nd ed., 1939, p 493.

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TABLE 1

PRELIMINARY TEST OF HARNESS

Type of Harness	SUBJECT K Harness Apron	 Harness Man	 Tump Line	SUBJECT S Harness Apron	 Harness Man	 Tump Line	Resting Man for Comparison
Distance Completed (Yds)	150	100	100	150	100	100	
Time/Yd Traveled (Sec)	1.23	1.50	1.17	1.11	1.28	1.13	
<u>Respiratory Data*</u>							
Tidal Volume (L)	1.83	1.78	2.00	2.19	1.60	1.47	0.5
Resp. Rate (/min)	32.4	33.2	29.8	33.3	39.8	35.1	14
Min. Vol. (L/min)	59.4	59.2	59.6	73.2	63.9	51.6	7.0
	9:00 AM	Noon					
Weather DB	36.0°F	50.0°F					
WB	34.5°	48.0°					

Subjects wore Combat Uniform C - No pack
Load: Sled with wood runners, weighted to 230 lbs
* Respiratory data are averages for entire course

From these observations which were confirmed by others not included in table, towing this heavy load uphill with poor footing was best accomplished with the Harness, Apron Type, Double Trace, Type 1. With it the distance traveled was 150 yards as compared with 100 yards for the Harness, Man, M-1944, Type 1 and for the Tump Line, and with one exception the speed was greater. The data with regard to respiration suggest some disadvantage from the Harness, Man, M-1944, Type 1 in the case of Subject S, whose respiratory rate was increased appreciably.

For the second test (Table 2) each man was required to pull a weighted sled over an 800 yard course with each of the different harnesses. His speed for this course was timed, and his pulse rate recorded at the beginning and end. After completing the 800 yards a nose clamp and rubber mouthpiece attached to a hose and valve assembly were fitted to permit the measurement of the volume of expired air through a gas flow meter, as was done for the first test. The subject then continued for an additional 90 seconds, pulling his load about 100 yards farther on flat ground, during which time the number of respirations were counted and the volume of expired air was measured. These respiratory

data are, therefore, measurements made at the end of a hard pull with each of the different styles of harness, and are representative of the strain imposed by each type under the arrangements of load and use. When these conditions were comparable, the respiratory data may be taken for purposes of rough comparison of effort and restriction imposed, but they do not provide precise, quantitative measure of the work involved. The order of testing was staggered, so that the environmental conditions might not too greatly influence the relative utility of the harnesses. However, in the case of Subject 4, the use of the apron type harness late in the morning when the ground was soft may be the explanation for its apparent inferiority to the Harness, Man.

TABLE 2

PERFORMANCE DATA FOR TOWING LOADS WITH DIFFERENT HARNESSES

	Subject 1			Subject 2			Subject 3		Subject 4	
	A	B	C	A	B	C	A	B	A	B
Load (Lbs)*	141	102	59	108	125	59	125	75	108	125
Time/800 yds (min)	16	12	12	12	15	12	30	28	23	18
Pulse - End of 800 yds	183	-	180	168	150	171	183	174	186	138
Respiratory Data:**										
Tidal Vol (L)	1.65	2.84	3.01	1.87	1.89	3.02	1.75	1.46	1.37	1.51
Resp Rate (/min)	31.1	16.7	16.0	28.7	26.6	15.3	26.0	24.7	27.4	24.0
Min Vol (L/min)	51.6	47.4	48.2	53.6	50.4	46.3	45.6	36.1	37.6	36.3
Order of Testing	1	5	9	6	2	10	3	8	7	4

A - Harness, Apron Type, Double Trace, Type 1
B - Harness, Man, M-1944, Type 1
C - Tump Line

Subjects 5 and 6 being smaller men, were unable to complete the course within reasonable time with loads comparable to the above, because of extended rest periods, and accordingly no data are presented for them.

Weather conditions:	Hours:	0930	1030	1115	1300	1445
	DB:	32°F	34	37	41.5	41
	WB:	30	31	33.5	36	36

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* Load lightened as day progressed to compensate for softening of ground, in the case of the two harnesses. For the Tump Line, 59 lbs represented the approximate maximum which could be negotiated. A minimum of 30 minute rest was granted after each test.

**Respiratory data are for performance at peak of fatigue, after load has been towed 800 yds.

TABLE 3

COMPARATIVE RESPIRATORY DATA FOR HARNESS, APRON TYPE, DOUBLE TRACE, TYPE 1, AND HARNESS, MAN, M-1944, TYPE 1,

(Average of Four (4) Subjects from Preceding Table)

	Harness, Apron Type Double Trace (Type 1)	Harness, Man M-1944 (Type 1)
Tidal Vol (L)	1.66	1.93
Resp Rate (/min)	28.4	23.0
Min Vol (L/min)	47.1	42.6

Part of these results are different from those of the first test, in that the respiratory rate with the Harness, Apron Type, Double Trace, Type 1, is more rapid than the rate with the Harness, Man, M-1944, Type 1, while in three (3) of the four (4) subjects the tidal volume is less. The respiratory minute volume on the other hand, is generally larger for the Harness, Apron Type, Double Trace, Type 1, just as it was in the first test.

For additional information, the vital capacity was measured for each subject under five (5) conditions:

(1) When wearing no harness;

(2) When wearing the Harness, Apron Type, Double Trace, Type 1, and pulling against a resistance with the torso;

(3) Same, but leaning forward so that the pull was effected by the shoulders;

(4) When wearing the Harness, Man, M-1944, Type 1, and pulling with the torso;

(5) Same, but pulling with the shoulders.

The resistance against which the subject pulled was a sled on which three (3) men stood to render it immobile. A ground brace was provided for each subject being tested to afford security of footing.

TABLE 4

VITAL CAPACITIES OF SUBJECTS PULLING WITH DIFFERENT TYPES OF HARNESS

(Values are in liters)

Subject	No Harness Control	Harness, Apron		Harness, Man	
		Pulling With Torso	Pulling With Shoulder	Pulling With Torso	Pulling With Shoulder
1	6.32	5.69	5.73	6.06	6.00
2	5.10	5.37	5.30	5.30	5.37
3	4.67	4.43	4.37	4.47	4.51
4	3.81	3.98	4.79	3.98	4.12
5	3.33	3.04	3.18	2.59	3.20
6	2.84	2.71	2.79	2.57	2.86
Avg	4.34	4.20	4.36	4.16	4.34

Subjects: 1 and 2 - over 6 feet tall
3 and 4 - approximately 5'9"
5 and 6 - approximately 5'4"

It may be observed that when the torso is used for pulling with either harness, the vital capacity is not significantly diminished, and when the pull is exerted by the shoulder rather than by the torso, as it would be with heavy loads or when going up hill, the average vital capacity is approximately the same as it is when no harness is worn. In general, measurements of vital capacity afford no striking evidence that pulling with body harness interferes with respiratory activity to any significant extent.

APPENDIX B

ANSWERS TO QUESTIONNAIRE SUBMITTED BY OQMG

1. Adjustment of harness for all sizes of soldiers:

a. The apron and strap portions of the Harness, Apron Type, Double Trace, Type 1, and the Harness, Man, M-1944, Type 1, fit all sizes of men satisfactorily. The subjects on whom this observation was made had the following characteristics:

Subject	Height	Weight
1	6'5"	190 lbs
2	6'2"	195
3	5'9½"	165
4	5'9"	137
5	5'4"	144
6	5'3"	130

However, the length of the traces, although satisfactory for the shorter men, are not suitable for the taller men. The 5-foot trace which is furnished, caused taller men to lift the sled off the ground with each step. In addition, the shorter the trace (and thus the larger the angle which the trace makes with the ground), the greater is the pull along the trace needed for displacing the load along the horizontal. This is seen in Fig 2, wherein the force vectors are diagramed.

Illustrative examples for men of two different heights are shown in Table 5. For this table, the assumptions are made (1) that a horizontal pull of 100 lbs is required to move a given load and (2) that the man pulling is inclined forward at an angle of 60°. For these conditions the table shows the beneficial effect of lengthening the traces.

TABLE 5

ADVANTAGE GAINED BY LENGTHENING HARNESS TRACES

Height of man	Force Required if Applied along Horizontal Direction of Motion	Approximate Force Required when Applied to Trace	
		Trace 5' long	Trace 7' long
5'4"	100 lbs	115 lbs	106 lbs
6'	100 lbs	130 lbs	110 lbs

Incl. #2

Obviously the longer the trace, the more nearly horizontal the pull. It is not to be inferred that the longer rope will greatly improve the ability of short men to tow a load otherwise unmanageable, since factors of strength, and of weight which determine traction, play a large role. However, a load which can just be towed with a shorter trace, may be towed with less fatigue using a longer trace.

2. Comfort:

As pointed out in Appendix 1, the principal disadvantage of Harness, Man, M-1944, Type 1, of importance sufficient to recommend its discontinuance, is the thrust which the body strap exerts against the abdomen when obstacles caused by irregularities of the ground are met. The effect is sudden increase of intra-abdominal pressure, and the interference with the inspiratory excursion of the diaphragm is much like that of a mild blow to the solar plexus.

Another cause of discomfort results from the fact that with heavy loads, a man does not stand sufficiently erect to pull with his torso, but leans far forward and exerts much of the pull with his shoulders. Consequently, the narrow harness shoulder straps cut into the shoulder, or compress his pack straps against that region. This difficulty can be partly overcome by removing the pack when heavy loads are being towed; however, measures directed toward better distribution of shoulder pressure would be helpful.

The harnesses were tested with subjects wearing Combat Uniform C, Belt, Pistol and Canteen, and Pack, Field. The men used service shoes, discarding their rubber overshoes because of inadequate footing. The harness did not interfere with any of this equipment, except in the case of the shoulder straps as noted above.

3. Traction:

Traction depends on the nature of terrain, the type of footgear, the weight of the load, and the weight of the man pulling the load. Harness traces which are too short might conceivably interfere with body balance, but scarcely with traction.

4. Should Harness and Toggle become a permanent accessory attachment of equipment to be towed:

Not determined in this test.

5. Durability and Replacement of Component Parts

Not determined in this test.

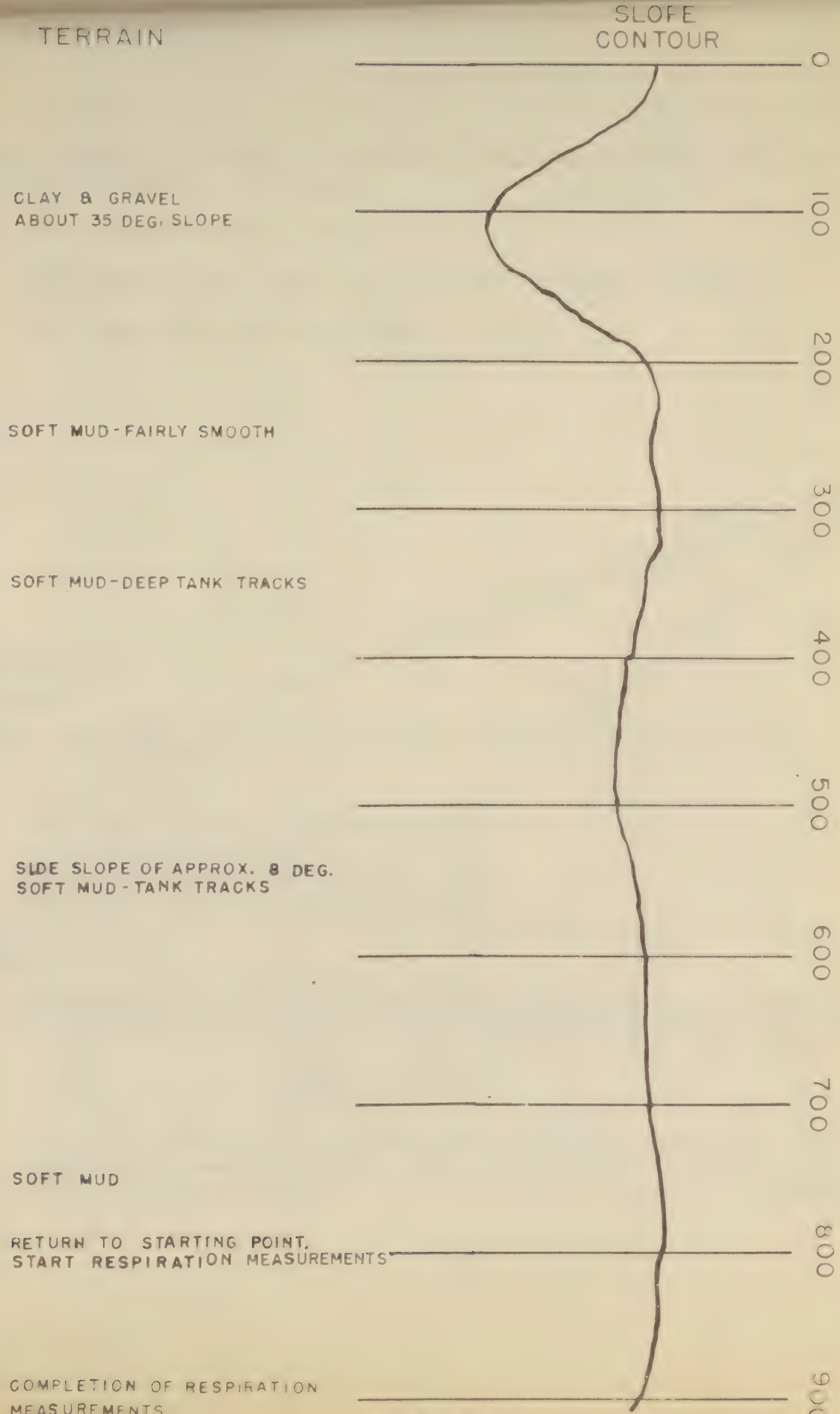


FIG. 1

PROFILE OF HARNESS TEST COURSE

FIG. I

Incl.# 3

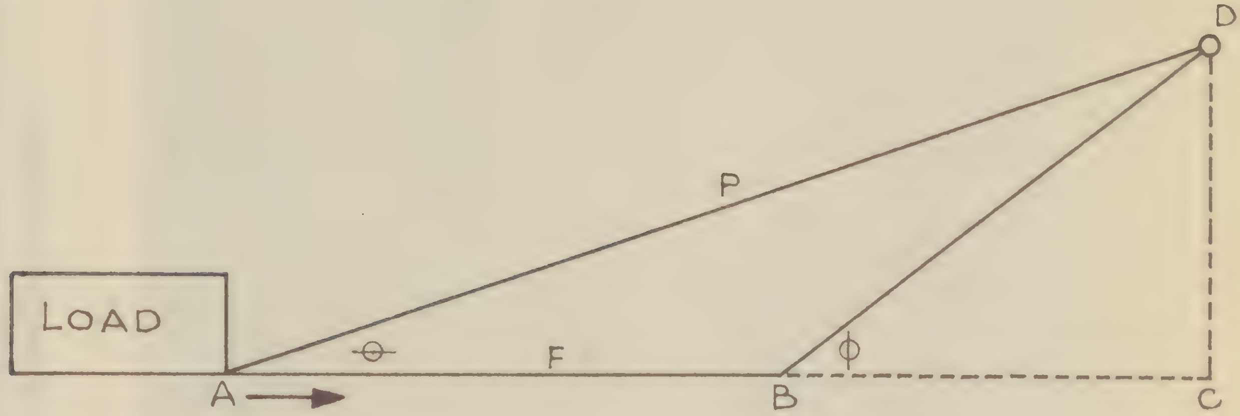
Figure 2

Vector diagram to indicate the influence of various factors on the force required to displace towed loads:

(1) Length of Harness Trace.

(2) Height of Man from Ground to Point of Harness Attachment.

(3) Angle of Inclination of Man.



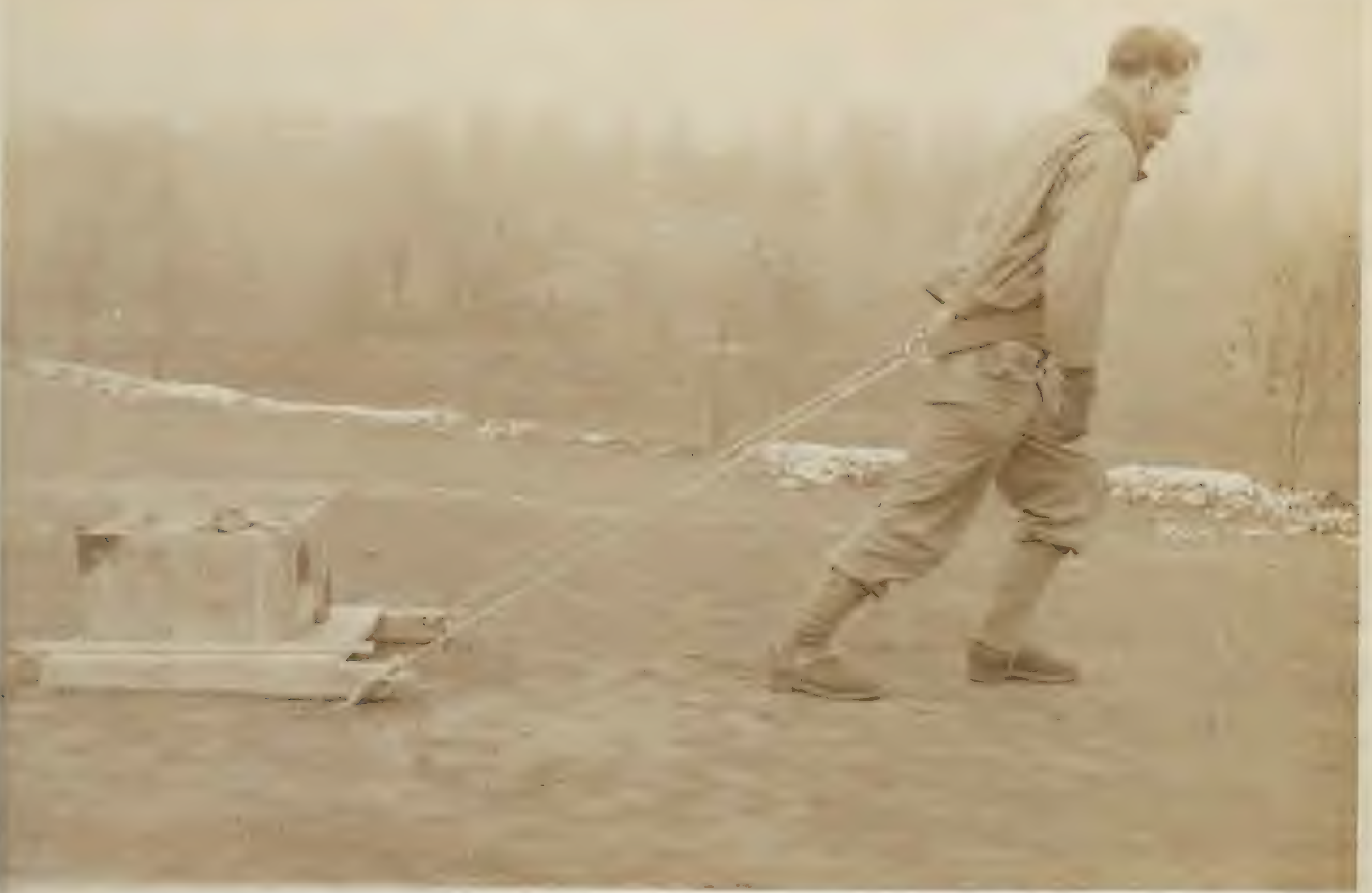
AD = Harness Trace, attached to Body at D.
B = Position of foot on ground.
DBC = ϕ = Angle of inclination of Body.
DAB = θ = Angle of trace with ground.

<u>Example</u>

Assuming that a force <u>F</u> directed along <u>AB</u> is required to displace the load in that direction, then the force <u>P</u> required when directed along <u>AD</u> is given by:

$$P = \frac{F}{\cos\theta}$$

Angle θ is derived from the magnitude of Angle ϕ. Angle ϕ in turn is determined by the tower's leg length <u>BD</u>, and the length of the trace <u>AD</u>, as well as by the foot traction available at <u>B</u>, and the slope of the terrain <u>AB</u>.



HARNESS, MAN, M-1944, TYPE 1

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FORT KNOX, KY.

Project No. T-8

Photo 1

HARNESS, APRON TYPE, DOUBLE TRACE, TYPE 1
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Photo 2

IMPROVISED TUMP LINE
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Photo 3